



This PDF file is an excerpt from the EPA sampling report entitled *Sampling Episode Report - Norwegian Star - Sampling Episode 6504* (March 2006). The full report can be downloaded from [http://www.epa.gov/owow/oceans/cruise\\_ships/finalstar.html](http://www.epa.gov/owow/oceans/cruise_ships/finalstar.html)

# **Sampling Episode Report Norwegian Star Sampling Episode 6504**

## **Chapter 3 Sample Collection Methodology**

**March 2006**

### **3.0                   SAMPLE COLLECTION AND ANALYSIS METHODOLOGY**

This section describes the sample collection and analysis methods and deviations from the ship-specific Sampling and Analysis Plan for Norwegian Star (Star SAP; Appendix E). A more detailed explanation of the sampling methodologies, analytes, and analytical methods, sampling frequency and duration, schedule, and logistics that were followed during sampling onboard the Star can be found in Section 3.0 of the Star SAP.

#### **3.1                   Pre-Sampling Activities**

EPA performed an engineering ship visit to the Star on May 18, 2004. The Star SAP was prepared based on information collected during that ship visit and from subsequent follow-up communication with Norwegian personnel. One week prior to the sampling episode, personnel conducted sampling setup activities onboard the Star, including loading sampling equipment and the onboard laboratory, inspecting the installed sampling ports, installing the strap-on ultrasonic flow meters, and installing and programming the automatic sampling machines.

#### **3.2                   Sample Collection And Analysis Methodologies**

In general, samples of graywater, influent to and effluent from the treatment system were taken for five consecutive 24-hour periods, while food pulper and wastewater treatment residual samples were taken for one 24-hour period, (see Tables 2-1 and 2-2). Various sample collection methods (described in Table 3-1) were used depending on the wastewater and the analyte (see Table 3-2). Most samples were composited over each 24-hour sampling period or were single grab samples in a 24-hour period. However, multiple (1 to 3) grab samples per 24-hour period were collected for pathogen indicator analyses because these samples must be analyzed within 6 hours of collection (see Table 3-2). Table 3-3 describes the analyte groups and lists the analytical methods used.

Each time a grab or grab composite sample was taken, another separate sample was placed in a separate container to perform field measurements of pH, temperature, conductivity, salinity, turbidity, sulfide, and free and total chlorine onboard. Temperature and pH were measured immediately at the sampling point, and the remaining parameters were measured at the sample staging area onboard. See Table 3-4 for equipment used for these measurements. Field measurements are used primarily to determine sample preservation requirements. Samples (other than those used for field measurements) were preserved in accordance with procedures described in the Star SAP (Appendix E), with the exception noted in Section 3.5 and Table 3-5. Note that while Alaska and Federal regulations for cruise ship discharges include standards for total residual chlorine, the equipment used to measure residual chlorine onboard was not suitable for measuring low levels of chlorine (detection limit of 20 µg/L compared to a standard of 10 µg/L) and was subject to various interferences, such as from oxidized forms of manganese. Accordingly, the field measurements collected during this sampling episode should not be used to assess compliance with cruise ship discharge standards.

Flow data were collected from the strap-on flow meters installed by the sampling team. See Section 2.4 for descriptions of the flow meter locations and Figures 2-1 and 2-2 for their locations. The flow meters were programmed to record the instantaneous flow rate (m<sup>3</sup>/min) and total flow (m<sup>3</sup>) every five minutes. Flow data recorded by the Star's pre-existing in-line flow meter could not be printed or downloaded for presentation and analysis in this report.

### **3.3            Quality Assurance/Quality Control**

Duplicate samples were collected for quality assurance and quality control. Results for duplicate samples were averaged. See Section 5.2.3 and Tables 5-4 and 5-5 for details on duplicate sampling. Other field quality control samples prepared for this sampling episode include a trip blank and an equipment blank, which are discussed in Sections 5.2.1 and 5.2.2, respectively.

### **3.4            Interview with the Ship's Crew**

The ship's crew was interviewed to obtain information regarding activities that impact wastewater generation. See Appendix C for details on these interviews and Section 4.2 for a summary.

### **3.5            Deviations from the Sampling and Analysis Plan**

The sampling episode proceeded as specified in the Star SAP with the deviations described in Table 3-5.

Table 3-1

## Sample Collection Method Descriptions, Norwegian Star

Sample Collection Method	Description
Composite by Flow	Flow-weighted composite samples were collected using an automatic sampling machine interfaced with an installed strap-on ultrasonic flow meter (see Section 2.4). The flow meter signaled the automatic sampling machine to collect a 250-mL sample aliquot each time a fixed quantity of wastewater passed through the wastewater pipe. The number of composite sample aliquots collected per 24-hour sampling period ranged from approximately 75 to 150, depending on the total volume of sample required for planned analyses for each sampling day. Sample aliquots were collected into a 10-L sample composite jar stored within the sampling machine. At the end of each 24-hour sampling period, the sample composite jar(s) were mixed and poured into individual sample bottles for analysis. Samples collected using the composite-by-flow method best represent a waste stream flowing through a pipe.
Grab	Grab samples were discrete samples collected directly into the sample bottles from the sample tap or through Teflon® tubing connected to the sample tap. Note that samples for pathogen indicator analyses were collected as grab samples (as opposed to composite samples) because they must be analyzed within a 6-hour holding time.
Grab Composite	Samples (1 to 4 per 24-hour sampling period) were manually collected as grab samples but composited either in the field or at the laboratory for a single analysis. The grab composite method was used when the composite-by-flow or composite-by-time methods were not appropriate. <b>Volatile organics</b> - grab samples were collected directly into sample vials, which were filled completely to avoid loss of target analytes by volatilization. Grab samples for each 24-hour period for analysis of volatile organics were composited by the laboratory for a single analysis. <b>Total and available cyanide</b> - grab samples were chemically preserved as soon as possible to minimize sample interferences. The preserved total and available cyanide grab samples for each 24-hour period were composited onboard by the sampling team for a single analysis. <b>Hexane extractable material/silica-gel treated hexane extractable material (HEM/SGT-HEM)</b> - grab samples were collected directly into sample containers to avoid loss of HEM/SGT-HEM that might adhere to the interior of any interim sampling container (e.g., sample composite jar). The sampling team prepared composite HEM/SGT-HEM samples onboard for a single analysis per sampling point per day by filling approximately one-fourth (250-mL) of the sample containers when they collected each grab sample, resulting in 1-liter of sample in each container at the end of each sampling period.

**Table 3-2**

**Sample Collection Methods and Analyte Groups Tested by Sampling Point,  
Norwegian Star**

Wastewater Name	Sampling Point # (a)(b)	Sample Collection Methods (c)	Analyte Groups Tested (d)	# of Days Sampled
Galley	SP-1	<b>Composite by Flow</b> Twenty-four-hour sampling periods began at 0600 each day.	Classical pollutants: - BOD <sub>5</sub> - Settleable residue - Group I - Group II Total and dissolved metals Semivolatile organics Pesticides	5
		<b>Grab composite</b> The collection times of the four subsamples in the composites each day can be found in Appendix A-3.	Classical pollutants: - HEM/SGT-HEM - Total and available cyanide Volatile organics	
		<b>Grab</b> Two grab samples were taken per sampling day. Results presented in Table 4-1 are an average for each sampling day. Results and collection times for each grab sample are presented in Appendix A-1.	Pathogen indicators	
Food Pulper	SP-2	<b>Grab composite</b> The collection times of the four subsamples in the composite sample can be found in Appendix A-3.	Classical pollutants: - BOD <sub>5</sub> - Settleable residue - Group I - Group II - HEM/SGT-HEM - Total and available cyanide Total and dissolved metals Volatile and semivolatile organics	1 (Day 3)
		<b>Grab</b> One grab sample was taken. Appendix A-1 shows the collection time.	Pathogen indicators	

(a) See Figures 2-1, 2-2, and 2-3 for simplified diagrams of the Star graywater and sewage CHT, wastewater treatment, and wastewater treatment residual handling systems indicating the sampling point locations.

(b) Two sampling point numbers indicate duplicate samples taken at this point for certain analytes. See Section 5.2.3 and Tables 5-4 and 5-5 for details on duplicate sampling.

(c) See Table 3-1 for descriptions of sample collection methods.

(d) See Table 3-3 for additional information regarding analytes tested and analytical methods used.

**Table 3-2 (Continued)**

Wastewater Name	Sampling Point # (a)(b)	Sample Collection Methods (c)	Analyte Groups Tested (d)	# of Days Sampled
Accommodations	SP-3	<b>Composite by Flow</b> Twenty-four-hour sampling periods began at 0600 each day.	Classical pollutants: - BOD <sub>5</sub> - Settleable residue - Group I - Group II Total and dissolved metals Semivolatile organics	5
		<b>Grab composite</b> The collection times of the four subsamples in the composites can be found in Appendix A-3.	Classical pollutants: - HEM/SGT-HEM - Total and available cyanide Volatile organics	
		<b>Grab</b> The number of grab samples taken per sampling day were as follows: 1, 2, 2, 2, 2. Results presented in Table 4-3 are an average for each sampling day (calculation used detection limits for nondetected results). Results and collection times for each grab sample are presented in Appendix A-1.	Pathogen indicators	
Laundry	SP-4	<b>Composite by Flow</b> Twenty-four-hour sampling periods began at 0600 each day.	Classical pollutants: - BOD <sub>5</sub> - Settleable residue - Group I - Group II Total and dissolved metals Semivolatile organics Dioxins and furans	5
		<b>Grab composite</b> The collection times of the four subsamples in the composites each day can be found in Appendix A-3.	Classical pollutants: - HEM/SGT-HEM - Total and available cyanide Volatile organics	
		<b>Grab</b> Two grab samples were taken per sampling day. Results presented in Table 4-4 are an average for each sampling day. Results and collection times for each grab sample are presented in Appendix A-1.	Pathogen indicators	

(a) See Figures 2-1, 2-2, and 2-3 for simplified diagrams of the Star graywater and sewage CHT, wastewater treatment, and wastewater treatment residual handling systems indicating the sampling point locations.

(b) Two sampling point numbers indicate duplicate samples taken at this point for certain analytes. See Section 5.2.3 and Tables 5-4 and 5-5 for details on duplicate sampling.

(c) See Table 3-1 for descriptions of sample collection methods.

(d) See Table 3-3 for additional information regarding analytes tested and analytical methods used.

**Table 3-2 (Continued)**

<b>Wastewater Name</b>	<b>Sampling Point # (a)(b)</b>	<b>Sample Collection Methods (c)</b>	<b>Analyte Groups Tested (d)</b>	<b># of Days Sampled</b>
Influent to Scanship Treatment System	SP-5	<b>Composite by Flow</b> Twenty-four-hour sampling periods began at 0600 each day.	Classical pollutants: - BOD <sub>5</sub> - Settleable residue - Group I - Group II Total and dissolved metals Semivolatile organics Pesticides Polychlorinated biphenyls	5
		<b>Grab Composite</b> The collection times for the four subsamples in the composites each day can be found in Appendix A-3.	Classical pollutants: - HEM/SGT-HEM - Total and available cyanide Volatile organics	
		<b>Grab</b> The number of grab samples taken per sampling day were as follows: 3, 2, 3, 3, 3. Results presented in Table 4-6 are an average for each sampling day. Results and collection times for each grab sample are presented in Appendix A-1.	Pathogen indicators	
Influent to UV Disinfection Part of Scanship Treatment System	SP-6	<b>Grab</b> Three grab samples were taken per sampling day. Results presented in Table 4-7 are an average for each sampling day (calculation used detection limits for nondetected results) . Results and collection times for each grab sample are presented in Appendix A-1.	Pathogen indicators	5

(a) See Figures 2-1, 2-2, and 2-3 for simplified diagrams of the Star graywater and sewage CHT, wastewater treatment, and wastewater treatment residual handling systems indicating the sampling point locations.

(b) Two sampling point numbers indicate duplicate samples taken at this point for certain analytes. See Section 5.2.3 and Tables 5-4 and 5-5 for details on duplicate sampling.

(c) See Table 3-1 for descriptions of sample collection methods.

(d) See Table 3-3 for additional information regarding analytes tested and analytical methods used.

**Table 3-2 (Continued)**

<b>Wastewater Name</b>	<b>Sampling Point # (a)(b)</b>	<b>Sample Collection Methods (c)</b>	<b>Analyte Groups Tested (d)</b>	<b># of Days Sampled</b>
Effluent from Scanship Treatment System	SP-7/ 8	<b>Composite by Flow</b> Twenty-four-hour sampling periods began at 0600 each day.	Classical pollutants: - BOD <sub>5</sub> - Settleable residue - Group I - Group II Total and dissolved metals Semivolatile organics	5
		<b>Grab Composite</b> The collection times of the four subsamples in the composites each day can be found in Appendix A-3.	Classical pollutants: - HEM/SGT-HEM - Total and available cyanide Volatile organics	
		<b>Grab</b> Three grab samples were taken per sampling day. Results presented in Table 4-8 are an average for each sampling day (calculation used detection limits for nondetected results). Results and collection times for each grab sample are presented in Appendix A-1.	Pathogen indicators	
Dried Wastewater Treatment Sludge	SP-9	<b>Grab</b> One grab sample was taken. Appendix A-3 shows the collection time.	Classical pollutants: - Group I - Group II - Total and available cyanide Total metals Volatile and semivolatile organics	1 (Day 1)
Incinerator Ash	SP-10	<b>Grab</b> One grab sample was taken. Appendix A-3 shows the collection time.	Total metals Semivolatile organics Dioxins and furans	2 (Day 1 and Day 4)

(a) See Figures 2-1, 2-2, and 2-3 for simplified diagrams of the Star graywater and sewage CHT, wastewater treatment, and wastewater treatment residual handling systems indicating the sampling point locations.

(b) Two sampling point numbers indicate duplicate samples taken at this point for certain analytes. See Section 5.2.3 and Tables 5-4 and 5-5 for details on duplicate sampling.

(c) See Table 3-1 for descriptions of sample collection methods.

(d) See Table 3-3 for additional information regarding analytes tested and analytical methods used.

**Table 3-2 (Continued)**

Wastewater Name	Sampling Point # (a)(b)	Sample Collection Methods (c)	Analyte Groups Tested (d)	# of Days Sampled
Source Water	SP-11	<b>Grab</b> One grab sample was taken. Appendix A-3 shows the collection time.	Pathogen indicators Classical pollutants: - BOD <sub>5</sub> - Settleable residue - Group I - Group II - Total and available cyanide Total and dissolved metals Volatile and semivolatile	1 (Day 4)
Trip Blank	SP-12	<b>Grab</b> One grab sample was taken. High performance liquid chromatography (HPLC) water was poured directly into sample vials in the contractor's Chantilly, VA sampling room and shipped to the Star. The trip blank was shipped back (unopened) to the laboratory along with the collected samples.	organics Volatile organics	1 (Day 3)
Equipment Blank	SP-13	<b>Grab</b> One grab sample was taken. The equipment blank consisted of HPLC water pumped through the automatic sampling machine and tubing and directly into sample bottles.	Total and dissolved metals Semivolatile organics	1 (Day 2)

(a) See Figures 2-1, 2-2, and 2-3 for simplified diagrams of the Star graywater and sewage CHT, wastewater treatment, and wastewater treatment residual handling systems indicating the sampling point locations.

(b) Two sampling point numbers indicate duplicate samples taken at this point for certain analytes. See Section 5.2.3 and Tables 5-4 and 5-5 for details on duplicate sampling.

(c) See Table 3-1 for descriptions of sample collection methods.

(d) See Table 3-3 for additional information regarding analytes tested and analytical methods used.

**Table 3-3**

**Analytes and Analytical Methods, Norwegian Star**

Analyte Group	Analytes	Analytical Method Number
Pathogen Indicators	<i>E. Coli</i>	EPA 9223B
	Enterococci	ASTM D6503-99
	Fecal Coliform	EPA 9222D
Classical Pollutants	Biochemical Oxygen Demand (BOD <sub>5</sub> )	EPA 405.1
	Settleable Residue (SS)	EPA 160.5
	Group I: - Total Suspended Solids (TSS) - Total Dissolved Solids (TDS) - Sulfate - Chloride - Alkalinity	EPA 160.2 EPA 160.1 EPA 375.4 EPA 325.3 EPA 310.1
	Group II: - Total Organic Carbon (TOC) - Chemical Oxygen Demand (COD) - Ammonia as Nitrogen - Nitrate/Nitrite as Nitrogen - Total Kjeldahl Nitrogen (TKN) - Total Phosphorus	EPA 415.1, Lloyd Kahn ("solids" sample) EPA 410.4 EPA 350.3 EPA 353.1 EPA 351.3 EPA 365.2
	Oil and grease measured as hexane extractable material and petroleum hydrocarbons measured as silica-gel treated hexane extractable material (HEM/SGT-HEM)	EPA 1664A
	Cyanide - Total cyanide - Available cyanide	EPA 335.2 EPA 1677
	Hardness	SM 2340B
Total and Dissolved Metals	See Appendix A-2 for complete list of metals analyzed.	EPA 200.7, EPA 200.9 (thallium), EPA 245.1 (mercury, "liquid" samples), EPA 245.5 (mercury, "solids" samples)
Volatile and Semivolatile Organics	See Appendix A-2 for complete list of volatile and semivolatile organics analyzed.	EPA 624 EPA 625
Pesticides	See Appendix A-2 for complete list of organohalide and organophosphorus pesticides analyzed.	EPA 1656A EPA 1657A
Polychlorinated Biphenyls (PCBs)	See Appendix A-2 for complete list of PCBs analyzed.	EPA 1668A
Dioxins and Furans	See Appendix A-2 for complete list of dioxins and furans analyzed.	EPA 1613B

**Table 3-4**

**Field Measurement Equipment, Norwegian Star**

<b>Parameter</b>	<b>Measured by:</b>
pH	Four-color pH paper
Temperature	Alcohol thermometer
Conductivity and salinity	Portable conductivity/salinity meter (YSI Model 30)
Turbidity	Pocket turbidimeter (Hach Cat. No. 52600-00)
Sulfide	Colorimeter (Hach DR 890)
Free and total chlorine	Pocket colorimeter (Hach Cat. No. 46700-00)

**Table 3-5**

**Deviations from the Sampling and Analysis Plan, Norwegian Star**

<b>Deviation</b>	<b>Description</b>
Pathogen Indicators Sample Collection	To conserve laboratory capacity, one rather than two grab samples of food pulper wastewater (a complex matrix with high solids content) was collected for pathogen indicators analyses. Additionally, one accommodations grab sample was missed due to lack of flow, and one influent to treatment grab sample was missed due to sampling error.
Pathogen Indicators Laboratory Duplicates	For 5% of the pathogen indicators samples, duplicate 100-mL sample volumes were taken with the intention that the laboratory would composite the 100-mL sample volumes and then analyze duplicate samples from each composite sample to evaluate laboratory precision (i.e., laboratory duplicates). However, the laboratory did not prepare composites, but instead analyzed each of the 100-mL sample volumes individually. Accordingly, the results obtained from these analyses are field duplicate samples, not laboratory duplicates, and are presented and handled as such in this report. See Section 5.2.3 and Table 5-5 for details on duplicate sampling for pathogen indicators.
Galley Wastewater (SP-1) Sampling Point Location	The galley wastewater sampling point and flow meter location was not properly identified during the pre-sampling ship visit; however, the correct location was identified and used during the sampling episode. The new sampling location was a dedicated galley wastewater transfer pump, and the flow meter was installed on the transfer pump's discharge pipe.
Food Pulper Wastewater (SP-2) Sampling Point Location	During the sampling episode, the sampling team determined that the sampling point location for the food pulper wastewater would not provide a representative sample. The original sampling point was located on a discharge pump from the food pulper wastewater holding tank. However, the discharge pump and discharge piping for this holding tank was not dedicated to food pulper wastewater (other wastewater streams, including sewage, were also discharged through the pump and piping). The food pulper wastewater samples were instead collected from one of the food pulper wastewater recirculation tanks; therefore, food pulper wastewater samples were not collected as discharged but as generated.
Accommodations Wastewater (SP-3) Tank Cleaning	The ship's crew cleaned the wastewater collection tank from which accommodations wastewater samples were being collected during the second day of sampling. The automatic sampling machine was paused during the cleaning activities.
Incinerator Ash (SP-10) Sample Collection	An incinerator ash sample was collected on Day 1; however, dried wastewater treatment sludge was not fed to the incinerator at that time because the centrifuge used for sludge dewatering was not working properly. A replacement incineration ash sample was collected on Day 4 when the Star resumed incineration of dried wastewater treatment sludge.
Volatile Organics Preservation	Free chlorine was detected in pre-sampling field tests at all sampling points. Based on these results, the sampling team prepreserved all volatile organics sample vials with sodium thiosulfate rather than waiting to determine preservation requirements based on the free chlorine field test results. Free chlorine was generally detected in grab samples collected throughout the sampling episode. (Sample vials were also prepreserved with hydrochloric acid to control biological activity as discussed in the Star SAP.)

**Table 3-5 (Continued)**

Deviation	Description
Analytical Methods	<p>EPA-contracted laboratories substituted comparable EPA analytical methods for certain analytes. Table 3-3 lists the actual analytical methods used by the laboratories.</p> <p>Note that while the Star SAP correctly listed EPA Methods 624 and 625 as the planned methods for analyzing volatile and semivolatile organics, respectively, Appendix E of the Star SAP mistakenly listed the target analytes for EPA Methods 1624 and 1625. Appendix A-2 of this report presents the actual list of target volatile and semivolatile organics.</p>
Sampling Schedule	<p>The sampling team adjusted the sampling schedule in Appendix C of the Star SAP to accommodate sampling logistics and ship operations. Refer to Appendix A-3 of this report for actual samples collected and sample collection dates/times.</p>